Technical Bulletin 82 January 1932

University of Minnesota
Agricultural Experiment Station

Observations on the Quantitative Changes in the Microflora During the Manufacture and Storage of Butter

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INTRODUCTION

In recent years, the presence and growth of micro-organisms in butter, as factors influencing its quality, have aroused renewed interest in the minds of those in the industry. It is known that micro-organisms may affect not only the flavor and aroma of butter, but also its appearance and physical condition. Since, in the opinion of the consumer, these are the principle factors determining the quality of butter, any deleterious change brought about by the action of micro-organisms may be of considerable financial importance to the creamery concerned.

With few exceptions, the undesirability of micro-organisms in butter is recognized; and at present mold and yeast counts are being used generally as a measure of the efficiency of pasteurization and sanitation. Attempts also have been made to use the counts as an index to the keeping quality of butter in storage, but this has not proved trustworthy.

The relationship of micro-organisms to the quality of butter has attracted the attention of investigators. Much work has been done and much remains to be done. There are many unsolved problems concerning the various flavors developing in butter, as well as changes in its physical condition, which may be the result of the action of micro-organisms.

The literature is replete with references to the microflora of butter. The authors have examined hundreds of papers pertinent to this investigation. However, no attempt will be made at this time to review them. The facts reported in subsequent pages of this bulletin are in general agreement with most of the recorded work.

PURPOSE OF THE STUDY

Any effort designed to reduce or eliminate the micro-organisms in butter must take into account their sources. One of the principal objects of this study was to evaluate the importance of the various materials, equipment, and processes involved in the manufacture of butter as scources of molds, yeasts, and bacteria in the finished product. The distribution of micro-organisms during the process of making butter, the seasonal variation in the number of micro-organisms in raw cream, and the efficiency of pasteurization were likewise considered.

It was desired, also, to record observations concerning the changes in the number of micro-organisms in butter during storage. Particular attention was paid to the comparative changes occurring in the microflora of unsalted and salted butters. Such observations were considered to be of value in planning further investigations dealing with the influence of the microflora on the deterioration of representative market grades of butter.

Observations were made under conditions more or less typical for Minnesota creameries at regular intervals and over a period of time sufficient to give data that would be indicative of results that might be expected under similar conditions of manufacture and storage of butter.

PLAN OF THE STUDY

In order that the results might be obtained, as nearly as possible, under conditions characteristic of Minnesota creameries, it was desirable that the work should be done in a typical commercial creamery. This introduced no difficulty, as the University of Minnesota supervises an experimental creamery established for such purposes at Albert Lea, Minnesota. This plant is operated essentially the same as the regular co-operative creameries of the state.

For the data dealing with the changes in the number of micro-organisms during the manufacture of butter, counts were made at different stages in the process. Mold, yeast, and bacterial counts were made of the raw cream, the cream after pasteurization and cooling, the cream in the churn, the buttermilk, and the butter. As a further check on the sources of micro-organisms in the creamery, mold and yeast counts were made of the rinsings from pipes, pumps, and churns. Likewise, counts were made of the water used for washing the butter, the salt, the air, and the parchment liners and circles used in the butter tubs.

Since a variation might be expected in the number of micro-organisms from season to season, data were taken monthly for a year to determine the facts. Observations were made on two to five consecutive lots of cream each month.

In order to determine the quantitative changes in the microflora of the butter during storage, two periods were used, one of thirty days, the other of nine months. For the butter stored thirty days, samples were taken from the butter made from the churnings of lots of cream observed for changes in the microflora during manufacture. One sample was taken before the salt was added and will be designated hereafter as "unsalted butter." The other sample was taken of the finished product, namely, the "salted butter." Mold, yeast and bacterial counts and chemical analyses of these samples were made immediately after churning. The butter after thoro chilling was then shipped to University Farm, St. Paul, and kept at 35° F. during the thirty-day period. Mold, yeast, and bacterial counts were made of these butters at the end of the thirty days storage.

Once each week, during the year in which the experiments were conducted, duplicate samples of unsalted and salted butters from the same churning were taken and shipped to University Farm. Mold, yeast, and bacterial counts and chemical analyses were made immediately after their receipt. The butter was then stored at 35° F. for nine months, after which counts were again made.

EXPERIMENTAL METHODS

Equipment for taking samples and making the desired counts was sterilized at University Farm, carefully packed, and shipped to Albert Lea for use at that point.

All samples were taken with every precaution to avoid contamination, and platings were made as promptly as possible. Samples of cream, buttermilk, and water were taken with sterile aluminum tubes and placed in sterile test tubes, plugged with cotton. Butter samples were taken with sterile wooden spatulas, and placed in sterile glass jars provided with aluminum screw caps.

Samples of cream were taken from the vat immediately before pasteurization and after the cream was pasteurized and cooled. For obtaining the pipe and pump rinse, 2 gallons of water (previously heated to 200-210° F. and then cooled) were pumped through the pipe line as assembled for pumping cream into the churn. A sample of this water after passage through the pipe was taken for plating. For the churn rinse, 8 gallons of water (treated as above) were revolved for three minutes in the churn after it was prepared for the cream. A sample of this rinse was taken for plating. Samples of cream in the churn were obtained after the churn had been in motion for three minutes. The samples of unsalted butter were taken after the butter had been worked for ten revolutions. Samples of the finished butter were taken after the salting and working processes were completed. Butter for storage was packed in three- and five-pound earthen jars and covered with double layers of parchment paper. Previous to use the jars and parchment paper were exposed in a cabinet to flowing steam for thirty minutes. Samples of storage butter were taken for analysis with sterile metal triers, and the butter was removed from the triers by means of sterile wooden spatulas.

Bacterial counts were made by using a modified official plate method. In the case of butter, the sample was warmed in a water bath at 37.8° C.

until melted and then thoroly stirred to form an emulsion before pipet-ting. Whey agar was used as the nutrient medium. The plates were incubated at room temperature (20-25° C.) for five days, and then for an additional forty-eight hours at 37.5° C. before counting.

Mold and yeast counts were made in a similar manner, except that one cubic centimeter of a one per cent solution of tartaric acid was added to each plate previous to the addition of whey agar. The plates were incubated at room temperature (20-25° C.) and counted after 3 days.

For counts on parchment paper, approximately one square inch, torn from the sheet by sterile forceps, was plated. For salt, approximately one gram was placed in the petri plate. For a mold count of the air a petri plate containing whey agar was exposed for ten minutes.

The Kohman method was used for the determination of moisture, fat, salt, and curd.

EXPERIMENTAL RESULTS

A. Changes in the Number of Micro-Organisms During the Manufacture of Butter

1. Sources of Micro-Organisms in Butter

a. Cream.—The possible sources of micro-organisms in butter naturally begin with the cream from which it is made. The complete data for the counts on raw and pasteurized cream are assembled in Appendix I. Data were collected for forty-five churnings during the course of a year.

Tables 1 and 2 show the distribution of the mold, yeast, and bac-terial counts of the raw and pasteurized cream according to the magni-tude of the count.

Table 1

Mold and Yeast Counts of Cream, Albert Lea, 1926-1927
(45 samples)

Counts	Distribution of samples according to			
	Mold counts		Yeast counts	
	Raw cream	Pasteurized cream	Raw cream	Pasteurized cream
per cc.	per cent	per cent	per cent	per cent
0	0.0	100.0	0.0	71.1
1- 9	6.7	0.0	0.0	13.3
10- 99	48.9	0.0	4.4	6.7
100-999	37.8	0.0	46.7	8.9
1,000 or more	6.6	0.0	48.9	0.0

Table 2
Bacterial Counts of Cream, Albert Lea, 1926-1927
(45 samples)

Bacterial counts	Distribution of samples according to bacterial count	
	Raw cream*	Pasteurized cream
per cc.	per cent	per cent
0-999	0.0	26.7
1,000-99,999	0.0	60.0
100,000-9,999,999	23.7	13.3
10,000,000 or more	77.3	0.0

* One sample missing.

It will be noted that the raw cream in every instance was heavily seeded with micro-organisms. The mold counts ranged from 2 to 32,000, with the greater percentage (48.9%) being over 10 but less than 100 per cubic centimeter. The yeast counts varied from 50 to 14,500, with the largest proportion (48.9%) over 1,000 per cubic centimeter. Bacterial counts ranged from 1,520,000 to 160,000,000, the majority (77.3%) being over 10,000,000 per cubic centimeter.

The counts on the pasteurized cream present a striking contrast to those on the raw cream. Apparently the molds were completely destroyed by pasteurization. The yeasts, tho somewhat more resistant than the molds, were completely eliminated in 71.1% of the lots of cream. The highest yeast count after pasteurization was 540; most of the remaining samples showed less than 10 per cubic centimeter. Of the bacterial counts, 26.7% were below 1,000, while 60% of the samples contained from 1,000 to 76,000 per cubic centimeter. The maximum bacterial count of pasteurized cream was 890,000 and the minimum 110.

In common with most of the co-operative creameries of Minnesota, the cream at Albert Lea is pumped directly from the weigh can to the horizontal-coil vat pasteurizers. The cream is pasteurized as soon as a vat is full, or after all the cream for the day has been received. Outlet valves on the vats are of the "flush" type. The pasteurization temperature used was either 150° F. for 30 minutes or else the cream was heated to 145° F. and then over a period of 30 minutes raised to 165° F. before cooling.

The efficiency of pasteurization for the various lots of cream is summarized in Table 3. As previously mentioned, pasteurization was 100 per cent effective against the molds. All the yeasts were destroyed in 71.1% of the samples. In one case, churning 93, there was no apparent destruction of yeasts, in fact, the count was somewhat higher following pasteurization. Pasteurization destroyed from 99.0 to 99.9% of the bacteria in 93.2% of the samples studied. The lowest efficiency of pasteurization in the destruction of bacteria was 94.2% for churning 415.

Table 3

Efficiency of Pasteurization of Cream as Judged by Percentage of Micro-organisms Destroyed, Albert Lea, 1926-1927 (45 samples)

Pasteurization efficiency	Distribution of samples according to pasteurizing efficiency against		
	Molds	Yeasts	Bacteria
per cent destroyed	per cent	per cent	per cent
100	100.0	71.1	0.0
99.0-99.9	0.0	11.1	93.2
98.0-98.9	0.0	8.9	2.3
Less than 98.0	0.0	8.9	4.5

Table 4 gives a comparison of the effect of the two temperatures on the percentage efficiency of pasteurization in the destruction of yeasts and bacteria. It will be noted that 150° F. for 30 minutes destroyed all of the yeasts in 87.5% of the samples, but when the cream was heated to 145° F. and then brought to 165° F. during a period of 30 minutes, this was the case for only 65.5% of the samples. This appeared to be to the advantage of the exposure at 150° F. for 30 minutes. There was no significant difference between the two methods in relation to the destruction of bacteria.

Table 4

Effect of Temperature of Pasteurization on Destruction of Yeasts and Bacteria (45 samples)

Pasteurization efficiency	Distribution of samples according to pasteurization efficiency at			
	150° F. for 30 min. for		145-165° F. for 30 min. for	
	Yeasts	Bacteria	Yeasts	Bacteria
per cent destroyed	per cent	per cent	per cent	per cent
100	87.5	0.0	65.5	0.0
99.0-99.9	0.0	93.3	10.4	93.1
98.0-98.9	6.8	6.7	13.8	0.0
Less than 98.0	6.7	0.0	10.3	6.9

The pasteurized cream is, directly, the original source of the micro-organisms in the butter in a creamery operating with modern methods. The counts on the raw cream show how serious it might be as a source of contamination if efficient pasteurization were not practiced. In this study, the pasteurized cream was in no instance a source of molds in the butter, because of effective pasteurization. In a few cases (28.9%), the pasteurized cream was a source of yeasts in the butter. As might be expected, however, the cream was a very fertile source of bacteria for, in the cream for nearly every churning, considerable numbers resisted pasteurization.

b. Pipes and pump.—Following the cream along the route through which it is taken in the plant, the pipes and pump used to transfer the cream from the vats to the churn appear as the next possible sources of contamination. The pipe and pump rinse previously described provides a check as to the molds and yeasts coming from this equipment. The results of such studies are given in Table 5. It will be seen that these pipes and pump were in unusually satisfactory condition and seldom contributed any significant amount of contamination to the cream. The results indicate that a pipe and pump line receiving proper attention with regard to cleaning and sterilization need not be an important source of molds and yeasts in cream. However, if not properly cared for, the pipes and pumps may readily harbor considerable numbers of micro-organisms, which may be carried into the cream and thence into the butter.

Table 5

Mold and Yeast Counts of Pipe Rinse, Albert Lea, 1926-1927

Month	Molds	Yeasts	Month	Molds	Yeasts
1926	per cc.	per cc.	1927	per cc.	per cc.
July	17	9	January	0	0
August	1	0	"	0	0
September	2	1	February	0	0
"	1	0	"	0	0
October	0	0	"	0	0
"	0	72	March	0	0
"	0	1	"	0	0
"	0	5	April	1	0
November	0	0	"	1	0
"	0	0	May	1	0
December	5	0	June	0	0
"	0	3	"	1	0

c. Churn.—The churn is the next important possibility as a source of micro-organisms in butter. Mold and yeast counts of the churn rinse were made at frequent intervals, with the results given in Table 6. The churn appeared to be a greater source of contamination than the pipes and pump and in several cases contributed significant numbers of molds and yeasts. In churning 413, 1,000 molds were found in each cubic centimeter of the churn rinse. This churning is of particular significance and will be discussed more fully later.

To indicate further the rôle of the churn in the contamination of cream, studies were made of the microflora of the cream after being revolved for several minutes in the churn. Differences between the counts of the pasteurized cream and the cream after contact with the churn might be taken as an indication of the amount of infection traceable to the churn. In such a comparison, allowance must be made for any contamination from the pipes and pump. As it has been shown in Table 5 that the latter were not particularly significant as sources of micro-organisms, wherever sizeable increases in counts were found they might be attributed largely to contamination from the churn.

Table 6

Molds and Yeasts in Churn Rinse, Albert Lea, 1926-1927

Churning number	Molds per cc.	Yeasts per cc.	Churning number	Molds per cc.	Yeasts per cc.
382	0	0	29	0	0
413	1,000	0	31	0	0
441	1	0	89	0	7
442	20	126	90	4	20
469	35	34	91	3	6
471	0	134	92	0	0
472	6	5	93	0	2
510	0	4	152	3	10
513	1	0	155	1	9
550	1	0	215	4	1
553	2	4	216	4	0
554	3	0	217	49	0
27	0	0	272	7	4
28	2	20	322	14	18

As no molds were found in the pasteurized cream in the vats, any molds in the cream in the churn must have come from sources beyond that point, principally pipes, pump, and churn. Appendix I shows the mold counts of the cream in the churn. The highest mold counts of the cream in the churn occurred most frequently when the counts in the churn rinse were high and the pipes and pump showed little contamination. The high count for churning 322 is perhaps explained by the possibility that, by chance in sampling, a portion of cream containing a mass of mold mycelium might have been found. Attention is called to the high mold count in churning 413, previously mentioned, in which the churn rinse indicated excessive contamination. This is an excellent illustration of what may happen when an idle churn is put into service without adequate preparation and sterilization. The creamery has two churns. The one in question had been idle for nearly two weeks, but had to be used for churning 413 because of a break-down of the other churn. The contamination occurring in churning 413 shows definitely what might be expected. Furthermore, to demonstrate how the cream and butter remove the major portion of the infection, note the data for churning 414. Immediately after removing the butter from churning 413, the churn was rinsed with warm water, scalded with boiling water and cooled, before adding the cream for churning 414. As will be noted, this lot of cream was not badly contaminated after such a procedure. Some molds were still being added but only a small fraction of those contributed to the previous churning.

The churn, occasionally, contaminated the cream with significant numbers of yeasts, as will be seen in Appendix II. In most cases, the oacterial count of the cream in the churn was somewhat higher than hat of the pasteurized cream in the vat. As no bacterial counts were nade of the pipe and pump rinse, this addition of bacteria must be a combination infection by pipes, pump, and churn but in only a few cases s the total contamination especially great. Appendix III illustrates this oint clearly.

To illustrate further the apparent relationship between the mold and east counts of the churn rinse and of the cream in the churn, observe he data in Table 7. When the mold or yeast counts are high in the hurn rinse there is a fairly noticeable tendency for the counts to be igh in the cream in the churn. Also, low counts in the cream in the hurn appear to be associated with low counts in the churn rinse. Thus, n the case of 77.8% of the samples of the cream in the churn having mold count of 0, the count of the churn rinse was 0 per cubic entimeter. Further, where the churn rinses showed 6 or more molds er cubic centimeter, 71.4% of the samples of cream in the same churn ad counts of 6 or more. The correlation is not so marked with the east counts but is suggestive. This may be due to the fact that the asteurized cream itself was a considerable source of yeasts.

Table 7

Relation Between Mold and Yeast Counts of Churn Rinse and Mold and Yeast Counts of Cream in Same Churn (29 samples)

Counts of churn rinse	Distribution of samples of cream in churn with: Mold count of			Yeast count of		
	0 per cc.	1-5 per cc.	6 or more per cc.	0 per cc.	1-5 per cc.	6 or more per cc.
per cc.	per cent	per cent	per cent	per cent	per cent	per cent
0	77.8	22.2	0.0	41.7	41.7	16.6
1-5	61.5	38.5	0.0	0.0	83.3	16.7
6 or more	14.3	14.3	71.4	36.4	27.2	36.4

d. **Wash water.**—The wash water was not found to be an imortant source of molds or yeasts in the butter. Only three samples ere found to contain molds and only one bore yeasts. The water was umped directly into the churn from a 100-foot well.

e. **Salt.**—The salt in every case was found to be free from molds nd yeasts. The concentration of salt in the agar may have exerted an hibiting effect upon the growth of organisms in the plate.

f. **Tubs and liners.**—Dry parchment liners were found to carry ome molds and yeasts, but after boiling in a strong brine solution they ere found to be sterile. Wooden tubs contained a few molds before eing treated, but after coating with hot paraffin they were not a source f contamination.

g. Air.—It is impossible to estimate the numbers of micro-organisms that may find their way into butter from the air at all points during the manufacture of butter. That the number may be of some consequence is shown in Table 8. The plates were exposed over the churns and vats and in the creamery cooler. The higher counts during the summer months are to be expected, owing to the greater prevalence of dust at that season.

Table 8

Number of Molds and Yeasts Falling on Petri Plates Exposed to Air Contamination for Ten Minutes, Albert Lea, 1926-1927

Month	Molds and yeasts on plates exposed					
	Over churn		Over vats		In refrigerator	
	Molds	Yeasts	Molds	Yeasts	Molds	Yeasts
	number	number	number	number	number	number
July	10	43	9	6	5	3
August	25	0	11	0	4	0
September	7	2	*	*	50	0
October	5	3	8	2	1	0
November	3	0	1	0	4	0
December	0	0	1	0	2	0
January	2	1	*	*	1	1
February	2	0	*	*	0	0
March	6	10	*	*	0	1
April	3	6	*	*	2	0

* No exposures made.

h. Miscellaneous.—There are, without doubt, other sources o micro-organisms in butter. However, no attempt was made to investi gate all the possibilities during these studies. Suffice to say, cleanlines and adequate sterilization must be the rule in the care of all equipmen and every precaution must be taken to protect the product during th process of manufacture, handling, and storage, so that it may not b unnecessarily exposed to infection.

i. Numbers of micro-organisms in fresh butter.—In Appendixe I, II, and III are shown the mold, yeast, and bacterial counts of butte both unsalted and salted, immediately after churning. These data ar summarized in Tables 9 and 10. The mold counts of unsalted butte ranged from 0 to 4,000, the yeast counts from 0 to 660, and the bacteri counts from 60 to 1,620,000 per cubic centimeter. No molds were foun in 28.9% and no yeasts in 17.8% of these unsalted samples. The mol counts of salted butter ranged from 0 to 4,000, the yeast count fro 0 to 1,180, and the bacterial counts from 250 to 101,000 per cubic centi meter. No molds were found in 24.5% and no yeasts in 11.1% o these salted samples. It will be noted in Appendix I that in most in stances the mold counts in the butter are higher than the mold count in the cream in the churn. Undoubtedly this is due to the fact tha additional molds are dislodged from remote parts of the churn during the churning process, especially when the workers are set into motion, or because aggregations of conidia are broken up to yield a larger number of colonies upon plating. In general, a similar situation occurs with respect to yeasts, as shown in Appendix II. As indicated in Table 9, there is a tendency for the salted butters to show fewer zero mold or yeast counts than the unsalted butters. This trend toward a slightly higher count in some of the salted samples may be attributed to the possibility that increased contamination occurs in the churn owing to the greater and more prolonged strain on the churn during the working process, with consequent further distribution of infected material. These phenomena are not so noticeable in the case of the bacterial counts, as indicated by Table 10. Naturally, many of these discrepancies, or fluctuations, may be explained on the basis of a marginal error in making analyses.

Table 9

Mold and Yeast Counts of Butter, Albert Lea, 1926-1927
(45 samples)

Count	Distribution of samples according to			
	Mold counts		Yeast counts	
	Unsalted butter	Salted butter	Unsalted butter	Salted butter
per cc.	per cent	per cent	per cent	per cent
0	28.9	24.5	17.8	11.1
1-9	35.6	48.9	48.9	44.4
10-99	33.3	24.4	15.5	26.7
100 or more	2.2	2.2	17.8	17.8

Table 10

Bacterial Counts of Butter, Albert Lea, 1926-1927
(45 samples)

Bacterial count	Distribution of samples according to bacterial count	
	Unsalted butter	Salted butter
per cc.	per cent	per cent
0-999	28.9	24.4
1,000-99,999	57.8	73.3
100,000 or more	13.3	2.3

The question also arises as to whether a slight or a considerable contribution of micro-organisms in butter from various sources may be reflected in a high or low count in the butter itself. For instance, may a high mold count in the butter be predicted from a high mold count in the churn rinse? A very close correlation of the counts on butter and any of the sources should not be expected, as the sources are numerous and the marginal error in the counts themselves seems to be large.

In Table 11 the mold counts of the unsalted and salted butters are grouped according to the counts from the corresponding churn rinse. For instance, 66.7% of the samples of unsalted butter with a mold count of 0 were associated with churn rinses showing a 0 count, and 100% of those with a mold count of 6 or more were associated with churn rinses showing 6 or more per cubic centimeter. In other words, there appeared to be an unexpectedly close correlation between the mold count of the churn rinse and that of the butter.

Table 11

Relation Between Mold Counts of Churn Rinse and Mold Counts of Butter (29 samples)

Mold count of churn rinse	Distribution of samples according to mold counts of butter: Unsalted butter, 0 per cc.	Unsalted butter, 1-5 per cc.	Unsalted butter, 6 or more per cc.	Salted butter, 0 per cc.	Salted butter, 1-5 per cc.	Salted butter, 6 or more per cc.
per cc.	per cent	per cent	per cent	per cent	per cent	per cent
0	66.7	11.1	22.2	44.4	33.3	22.3
1-5	20.0	26.7	53.3	13.4	53.3	33.3
6 or more	0.0	0.0	100.0	0.0	0.0	100.0

A similar condition does not appear for the yeast counts, as shown in Table 12. This may be explained on the basis that the cream before passing into the churn already had a considerable, tho variable, number of yeasts. This might mask the effect of the churn.

Table 12

Relation Between Yeast Counts of Churn Rinse and Yeast Counts of Butter (29 samples)

Yeast count of churn rinse	Distribution of samples according to yeast counts of butter: Unsalted butter, 0 per cc.	Unsalted butter, 1-5 per cc.	Unsalted butter, 6 or more per cc.	Salted butter, 0 per cc.	Salted butter, 1-5 per cc.	Salted butter, 6 or more per cc.
per cc.	per cent	per cent	per cent	per cent	per cent	per cent
0	16.6	41.7	41.7	8.3	50.0	41.7
1-5	33.3	33.4	33.3	0.0	16.7	83.3
6 or more	9.1	27.3	63.6	9.1	9.1	81.8

Similar relationships appear in Tables 13 and 14. The correlation again is positive in the case of the mold counts of the cream in the churn and the butter. The yeast counts show a tendency here to correspond more closely to the relationships shown by the mold counts than they did in the previous comparison.

Table 15 marks a comparison between the bacterial counts of the cream in the churn and those of the butter. Here there is a slight correlation intermediate between that shown by the comparisons in mold or yeast counts.

Table 13

Relation Between Mold Counts of Cream in Churn and Mold Counts of Butter (45 samples)

Mold count of churn rinse	Distribution of samples according to mold counts of butter					
	Unsalted butter			Salted butter		
	0 per cc.	1-5 per cc.	6 or more per cc.	0 per cc.	1-5 per cc.	6 or more per cc.
per cc.	per cent	per cent	per cent	per cent	per cent	per cent
0	44.0	32.0	24.0	44.0	44.0	12.0
1-5	13.3	6.7	80.0	0.0	33.0	66.7
6 or more	0.0	0.0	100.0	0.0	0.0	100.0

Table 14

Relation Between Yeast Counts of Cream in Churn and Yeast Counts of Butter (45 samples)

Yeast count of churn rinse	Distribution of samples according to yeast counts of butter					
	Unsalted butter			Salted butter		
	0 per cc.	1-5 per cc.	6 or more per cc.	0 per cc.	1-5 per cc.	6 or more per cc.
per cc.	per cent	per cent	per cent	per cent	per cent	per cent
0	35.7	35.7	28.6	28.6	28.6	42.8
1-5	20.0	46.7	33.3	6.7	40.0	53.3
6 or more	0.0	12.5	87.5	0.0	6.2	93.8

Table 15

Relation Between Bacterial Counts of Cream in Churn and Bacterial Counts of Butter (45 samples)

Bacterial count of cream in churn	Distribution of samples according to bacterial counts of butter					
	Unsalted butter			Salted butter		
	0-4,999 per cc.	5,000-24,999 per cc.	25,000 or more per cc.	0-4,999 per cc.	5,000-24,999 per cc.	25,000 or more per cc.
per cc.	per cent	per cent	per cent	per cent	per cent	per cent
0-4,999	94.4	0.0	5.6	61.1	38.9	0.0
5,000-24,999	60.0	40.0	0.0	90.0	10.0	0.0
25,000 or more.....	35.3	11.8	52.9	35.3	17.6	47.1

These data show, in a general way, that a determination of the numbers of micro-organisms in the churn rinse or in the cream in the churn makes it possible to predict reasonably well what count may be expected in the finished butter.

2. The Distribution of Micro-organisms During the Churning of Butter

Analysis of the distribution of the micro-organisms during the manufacture of butter is complicated because organisms are added to the cream during the process of churning. This is true, particularly, with respect to molds and yeasts. Molds in the cream after pasteurization, in these studies, were apparently there as the result of re-contamination. This likewise seemed to be true of the yeasts in 71.1% of the churnings. A comparison may be made, however, of the number of micro-organisms retained in the buttermilk and in the butter. This comparison is shown in Table 16. There is a noticeable tendency for the buttermilk to retain the greater number of micro-organisms. For example, 28.9% of the unsalted and 24.5% of the salted butter samples contained no molds; only 15.6% of the buttermilk samples gave a zero mold count. The same general situation applies to the yeast and bacterial counts. There was a larger percentage of high counts in the buttermilk than in the butter.

Table 16

Comparison Between Counts of Butter and Buttermilk (45 samples)

Per cc.	Distribution of samples according to count		
	Unsalted butter	Salted butter	Buttermilk
Mold Count	per cent	per cent	per cent
0	28.9	24.5	15.6
1-9	35.6	48.9	28.9
10-99	33.3	24.4	40.0
100 or more	2.2	2.2	15.5
Yeast Count			
0	17.8	11.1	8.9
1-9	48.9	44.4	31.1
10-99	15.5	26.7	46.7
100 or more	17.8	17.8	13.3
Bacterial Count			
0-999	28.9	24.4	6.7
1,000-99,999	57.9	73.3	71.1
100,000 or more	13.2	2.3	22.2

To illustrate this point in another way, note the data in Table 17. They show that the mold counts of 66.7%, the yeast counts of 64.4%, and the bacterial counts of 86.7% of the samples of buttermilk were higher than the respective counts of the unsalted butter from which the buttermilk was drawn. A similar relationship exists between the counts of buttermilk and salted butter.

Table 17

Relation Between Counts of Butter and of Buttermilk from Same Churning

Counts	Compared with counts of unsalted butter			Compared with counts of salted butter		
	Buttermilk counts were			Buttermilk counts were		
	Higher	Lower	Same	Higher	Lower	Same
	per cent	per cent	per cent	per cent	per cent	per cent
Mold	66.7	11.1	22.2	64.4	8.9	26.7
Yeast	64.4	26.7	8.9	55.6	37.8	6.6
Bacterial	86.7	13.3	0.0	84.4	15.6	0.0

It is interesting to note, in Appendix I, that the mold counts of the finished butter are in many instances greater than those of the cream in the churn. This indicates, distinctly, the importance of the churn as a source of mold and especially the incorporation of infection during the working process. A glance at the buttermilk counts will reveal the rather marked accumulation of molds from the churn. Appendix II gives data that show that a similar phenomenon occurs in relation to the yeast counts. The butter, salted or unsalted, in both instances contains much more than the expected proportion of yeasts and molds, altho the difference between the counts of the buttermilk and the butter is not numerically great.

A different situation arises in respect to the bacterial counts as shown in Appendix III. In the majority of cases, the bacterial count of the butter is lower than that of the cream in the churn. This leads one to believe that the churn was not so important a factor as a source of bacteria in the butter as it was in the case of molds and yeasts. The bacteria added from the churn apparently were largely of surface origin and were not deeply buried in the moving parts, such as the workers, as, apparently, had been the case with the molds and yeasts. The differences between the bacterial counts of butter and buttermilk were much greater numerically than they were in the case of the mold and yeast counts.

B. Seasonal Variations

The possibility of a seasonal variation in the number of microorganisms in raw cream as delivered at this particular creamery was suggested by the extreme fluctuation between summer and winter temperatures in the vicinity of Albert Lea. These temperature ranges are shown in Table 18. They are the mean monthly temperatures at Albert Lea as recorded by the United States Weather Bureau during the course of these studies. In Table 19 the mold, yeast, and bacterial counts are arranged in two groups, those in one group representing what might be considered low and the other high counts. Then these groups were subdivided according to season, so the table shows the percentage of high- and low-count samples during the four seasons of the year. The spring season included March, April, and May, with an average mean temperature of 45.8° F.; summer as June, July, and August with 69.6° F.; fall as September, October, and November with 45.1° F.; and winter as December, January, and February with 19.1° F. All counts were highest in the summer months, as one might readily anticipate. The lowest mold counts occurred in the winter. The fact that the greatest proportion of low yeast and bacterial counts appeared in the fall may be explained on the basis of cool nights, and more effective cooling methods. During the winter months cream is seldom cooled properly, as the dairymen have a tendency to keep it where it will not freeze and in doing so often expose it to temperatures favorable for the growth of yeasts and bacteria. It is probably for this reason that these counts are so high in the colder weather. One might venture the opinion that the contamination of the cream with molds was less in the winter, consequently the mold counts did not show this tendency to be high in the winter. Apparently there is a noticeable seasonal variation in the number of micro-organisms in cream.

Table 18

Mean Monthly Temperatures at Albert Lea

Month	Temperature, ° F.	Month	Temperature, ° F.
1926		1927	
July	73.2	January	16.0
August	71.0	February	25.4
September	59.2	March	36.6
October	48.0	April	46.6
November	28.1	May	54.3
December	15.9	June	64.6

Table 19

Counts of Raw Cream at Various Seasons of the Year (45 samples)

Season	Distribution of samples according to					
	Mold counts		Yeast counts		Bacterial counts	
	Less than 100 per cc.	100 or more per cc.	Less than 1,000 per cc.	1,000 or more per cc.	Less than 10,000,000 per cc.	10,000,000 or more per cc.
	per cent	per cent	per cent	per cent	per cent	per cent
Spring	66.7	33.3	66.7	33.3	16.7	83.3
Summer	0.0	100.0	10.0	90.0	0.0	100.0
Fall	70.0	30.0	70.0	30.0	70.0	30.0
Winter	76.9	23.1	53.8	46.2	7.7	92.3

C. Changes in the Number of Micro-organisms During Storage

The complete data for the changes occurring in the number of micro-organisms in the butter in storage are to be found in Appendixes IV to VII.

1. Butter Stored for One Month

The changes in count in the butter stored at 35° F. for one month are shown in Appendixes IV and V, and summarized in Table 20. There was a general and marked increase in the counts of the unsalted butter during the storage period. As will be noted, only 2.2% of the samples of unsalted butter had mold counts greater than 100 per cubic centimeter when fresh; after storage 42.2% of the samples had such high counts. The most striking increases occurred in the bacterial counts (Table 20).

Table 20

Counts of Butter Before and After Storage for One Month (45 samples)

Counts	Distribution of samples according to count of			
	Unsalted butter		Salted butter	
	Fresh	After 1 month	Fresh	After 1 month
per cc.	per cent	per cent	per cent	per cent
Mold Count				
0	28.9	11.2	24.5	31.1
1-9	35.6	24.4	48.9	53.3
10-99	33.3	22.2	24.4	11.1
100 or more	2.2	42.2	2.2	4.5
Yeast Count				
0	17.8	8.9	11.1	24.4
1-9	48.9	13.3	44.4	53.3
10-99	15.5	31.1	26.7	20.0
100 or more	17.8	46.7	17.8	2.3
Bacterial Count				
0-999	31.1	0.0	24.4	44.4
1,000-99,999	55.6	17.8	73.3	55.6
100,000 or more	13.3	82.2	2.3	0.0

Contrasted with these changes are those occurring in the salted but-er, in which the tendency is toward a decrease in counts during storage. This situation is most striking when the counts in the unsalted and alted butters are compared after storage. These differences are to be xpected.

In order to illustrate these tendencies in another way, the data were nalyzed as shown in Table 21. Here a comparison is made between he salted and unsalted butters to show the percentage of samples in vhich the counts increased, decreased, or remained the same during torage. It will be seen that 73.3% of the unsalted samples showed ncreased mold counts after one month's storage while 66.7% of the alted samples showed decreases. The same phenomenon occurs with he yeasts and bacteria.

Table 21

Quantitative Changes in the Microflora of Butter During Storage of One Month (45 samples)

Counts	Type of butter	Distribution of samples according to changes in count		
		Increasing	Decreasing	No change
		per cent	per cent	per cent
Mold	Unsalted	73.3	20.0	6.7
Mold	Salted	24.4	66.7	8.9
Yeast	Unsalted	71.1	22.2	6.7
Yeast	Salted	11.1	80.0	8.9
Bacterial	Unsalted	93.3	6.7	0.0
Bacterial	Salted	24.4	73.3	2.3

An idea of the extent of the increases or decreases in the count during the storage period may be gained by a study of Table 22. I making these comparisons a ratio was determined between the origina and final counts of each sample, in the following manner: The "X" unknown, represented the final count in terms of the original. Thus if the original count was 1 and the final 10, then the ratio was calcu lated as 1:10, or X = 10.0; if, on the other hand, the original was 1 and the final 1, then the ratio became 10:1, so that X = 0.1. If n change occurred in the count, X = 1.0. When the original or fina count was zero (0), the calculations were based, arbitrarily, on change from, or to, one (1). By this simple method it was considered possibl to express the relative magnitude of the decrease or increase. Accord ing to Table 22 it appears that the ratio of increase in the unsalte butter was greatest for the bacteria. A larger proportion of the sample showed considerable increases in count. The ratios for the salted butte show clearly that where increases did occur they were not nearly s great as they had been in the unsalted butter. None of the salte samples showed 100 fold increases; in many of the unsalted butters th counts increased over 1,000 times their original magnitude, in fac 35.6% of the bacterial counts showed such a marked change.

Table 22

Extent of Quantitative Changes Taking Place in the Microflora of Butter During Storage for One Month
(45 samples)

Ratio	Distribution of samples according to ratio of increase or decrease in counts					
	Unsalted butter			Salted butter		
	Molds	Yeasts	Bacteria	Molds	Yeasts	Bacteria
X	per cent	per cent	per cent	per cent	per cent	per cent
0.01-0.99*	20.0	22.2	6.6	66.7	80.0	73.3
1.00-99.9†	53.3	53.3	26.7	33.3	20.0	26.7
100-999†	22.2	24.5	31.1	0.0	0.0	0.0
1,000 or more†	4.5	0.0	35.6	0.0	0.0	0.0

* Represents decreasing counts.
† Represents increasing counts.

In a further attempt to point out the effect of salt on the growth o micro-organisms in butter during storage, a study of the data was mad to determine the relation between the salt content and the tendenc toward increasing or decreasing counts. This material is presented i Table 23. Here it will be seen that the salt in the butter did not exer an inhibitory effect in direct proportion to its concentration, especiall on molds. It appears that the small amount of salt is nearly as effectiv as a greater amount. The effect of salt could be more accurately gauge by a determination of the concentration of the salt in the aqueous frac ion of butter, in other words, the concentration of brine. Such a calcu-ation was made but the results showed exactly the same trend as the ata in Table 23.

Table 23

Relation of Salt Content to Changes Taking Place in Counts of Butter During Storage for One Month (45 samples)

Salt content	Distribution of samples according to changes in								
	Mold counts			Yeast counts			Bacterial counts		
	Increasing	Decreasing	No change	Increasing	Decreasing	No change	Increasing	Decreasing	No change
per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
0.0........	73.3	20.0	6.7	71.1	22.2	6.7	93.3	6.7	0.0
2.0-2.4.....	14.3	85.7	0.0	14.3	85.7	0.0	28.6	71.4	0.0
2.5-2.9.....	31.0	62.1	6.9	13.8	72.4	13.8	24.1	75.9	0.0
3.0-3.7.....	0.0	77.8	22.2	0.0	100.0	0.0	22.2	66.7	11.1

Without exception the flavor of the salted butter after one month's torage at 35° F. was good, altho some samples showed indications of taleness. Sharply in contrast with this, the unsalted butter showed narked defects in most cases. Thirty-four out of 45 samples were riticised as cheesy; 9 more were only fair or slightly unclean in flavor. 'wo samples appeared to retain their original desirability. Thus it is lear that salt did play an important part in the keeping quality of this utter. The relationship between the development of the organisms in he butter and the appearance of flavor defects is, at least, suggestive.

2. Butter Stored for Nine Months

The counts for the butters stored at 35° F. for nine months are etailed in Appendixes VI and VII and summarized in Table 24. Again here was a marked increase in the percentage of samples of unsalted utter showing higher counts after storage, especially in the case of he molds. For the salted butters after nine months, there was a greater ercentage of samples with the lowest range of counts. Interestingly nough, however, there appeared, on the other hand, a larger number f the highest group of counts than there had been when the butter was resh. For example, only 1.5% of the salted samples had mold counts f 100 or more before storage, whereas, after storage 9.4% of the counts vere in that category.

Table 25 shows that there was not such a marked difference be-ween the percentage of samples increasing in count in the unsalted and he salted butters as there had been in the case of the butters stored or one month (see Table 21).

Table 24

Counts of Butter Before and After Storage for Nine Months (64 samples)

Counts	Distribution of samples according to count of			
	Unsalted butter		Salted butter	
	Fresh	After 9 months	Fresh	After 9 month[s]
per cc.	per cent	per cent	per cent	per cent
Mold Count				
0	14.1	1.5	26.6	42.2
1-9	37.5	4.7	59.4	34.4
10-99	34.4	6.3	12.5	14.0
100 or more	14.0	87.5	1.5	9.4
Yeast Count				
0	6.3	17.1	7.8	51.6
1-9	23.4	6.3	50.0	14.1
10-99	48.4	14.0	34.4	20.3
100 or more	21.9	62.5	7.8	14.0
Bacterial Count				
0-999	3.1	3.1	25.0	57.8
1,000-99,999	32.8	21.9	71.9	35.9
100,000 or more	64.1	75.0	3.1	6.3

Table 25

Quantitative Changes in the Microflora of Butter During Storage for Nine Months (64 samples)

Counts	Type of butter	Distribution of samples according to changes in count		
		Increasing	Decreasing	No change
		per cent	per cent	per cent
Mold	Unsalted	95.3	4.7	0.0
Mold	Salted	40.6	46.9	12.5
Yeast	Unsalted	68.8	29.7	1.5
Yeast	Salted	31.2	64.1	4.7
Bacterial	Unsalted	53.1	46.9	0.0
Bacterial	Salted	25.0	73.4	1.6

To indicate the extent of decrease or increase in count, Table 26 i[s] presented. The percentage of samples of unsalted butter showing mol[d] and yeast counts augmented 1,000 fold or more was much greater tha[n] it was for the butter stored for one month. On the other hand, th[e] bacterial counts responded in the opposite direction. Where increase[s] occurred they were chiefly within the range below 100 fold. In th[e] salted butter, a few samples showed marked increases in counts, but th[e] general tendency was for decreases or moderate multiplication. Never[-] theless, a small percentage of salted samples showed decreases in mol[d] or yeast counts than had been the case with butter stored for one month

Table 26

Extent of Quantitative Changes Taking Place in the Microflora of Butter During Storage for Nine Months (64 samples)

Ratio	Distribution of samples according to ratio of increase or decrease in counts					
	Unsalted butter			Salted butter		
	Molds	Yeasts	Bacteria	Molds	Yeasts	Bacteria
X	per cent	per cent	per cent	per cent	per cent	per cent
0.01-0.99*	4.6	29.7	46.9	57.8	67.2	73.4
1.00-99.9†	31.3	46.9	42.2	37.5	28.1	23.5
100-999†	26.6	12.5	7.8	3.1	3.1	3.1
1,000 or more†	37.5	10.9	3.1	1.6	1.6	0.0

* Represents decreasing counts.
† Represents increasing counts.

The effect of the salt upon the counts is shown in Table 27. There ppears to be some correlation between the salt content and the change count. This is least noticeable in the case of the mold counts, which in line with the previous observations. Salt apparently exerted an ffect in some proportion to the increase in concentration.

Table 27

Relation of Salt Content to Changes Taking Place in Counts of Butter During Storage of Nine Months (64 samples)

Salt content	Distribution of samples according to changes in								
	Mold counts			Yeast counts			Bacterial counts		
	Increasing	Decreasing	No change	Increasing	Decreasing	No change	Increasing	Decreasing	No change
per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
0	95.3	4.7	0.0	68.8	29.7	1.5	53.1	46.9	0.0
1.7-2.4.....	57.1	33.3	9.6	45,0	50.0	5.0	35.0	60.0	5.0
2.5-2.9.....	31.3	50.0	18.7	28.1	65.6	6.3	25.0	75.0	0.0
3.0-3.2.....	36.4	63.6	0.0	16.7	83.3	0.0	8.3	91.7	0.0

D. Influence of Age of Butter at the Time of Original Count on Change Taking Place During Storage

The samples of butter stored for nine months, because of the force f circumstances, were of various ages before the original count was aken. This situation should be taken into account to determine whether r not extensive changes in count might have occurred in the samples uring the first few days. From Table 28, one can see that the age of he unsalted butter at the time of the original count had little effect pon later changes in the mold count. As usual, the yeasts gave erratic esults and one can see very little correlation in this case. However, the ituation concerning the bacterial counts was quite striking. All the samples of unsalted butter examined immediately after churning showe an increased bacterial content after storage. Samples that were te days or more old before plating consistently gave decreased counts i storage. On the other hand, as Table 29 indicates, the same phenomeno did not appear in the salted butters. There did not seem to be any re lationship between the age of this butter at the time of making th original count and the changes occurring in storage.

Table 28

Relation Between the Age of Butter at the Time of Original Count and th Change Taking Place in the Number of Micro-organisms in Unsalted Butter During Storage for Nine Months (64 samples)

Age of butter at time of original count	Distribution of samples according to age at time of original count and changes taking place in count						
	Mold counts		Yeast counts			Bacterial counts	
	In-creasing	De-creasing	In-creasing	De-creasing	No change	In-creasing	De-creasing
days	per cent	per cent	per cent	per cent	per cent	per cent	per cent
0	100.0	0.0	50.0	50.0	0.0	100.0	0.0
1-3	100.0	0.0	85.7	14.3	0.0	71.4	28.6
4-6	95.7	4.3	78.3	17.4	4.3	65.2	34.8
7-9	89.5	10.5	73.7	26.3	0.0	42.1	57.9
10-12	100.0	0.0	33.3	66.7	0.0	0.0	100.0
13-16	100.0	0.0	33.3	66.7	0.0	0.0	100.0

Table 29

Relation Between the Age of Butter at the Time of Original Count and th Change Taking Place in the Number of Micro-organisms in Salted Butter During Storage for Nine Months (64 samples)

Age of butter at time of original count	Distribution of samples according to age at time of original count and changes taking place in count								
	Mold counts			Yeast counts			Bacterial counts		
	In-creas-ing	De-creas-ing	No change	In-creas-ing	De-creas-ing	No change	In-creas-ing	De-creas-ing	No change
days	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cen
0	33.3	66.7	0.0	16.7	83.3	0.0	0.0	100.0	0.0
1-3	28.6	42.8	28.6	57.1	42.9	0.0	28.6	71.4	0.0
4-6	56.5	34.8	8.7	26.1	65.2	8.7	26.1	73.9	0.0
7-9	21.1	57.9	21.0	31.6	63.2	5.2	31.6	68.4	0.0
10-12	33.0	66.7	0.0	0.0	100.0	0.0	0.0	100.0	0.0
13-16	33.0	66.7	0.0	50.0	50.0	0.0	33.3	50.0	16.7

These data indicate that a mold or a bacterial count of unsalted but- ter should be made as soon as possible after churning if one is to use these counts as indices of sanitation.

E. Comparison of Changes in Count During One Month's and Nine Months' Storage

In four instances, the same lots of butter were stored for both eriods, namely, one and nine months. The butter was plated immeditely after its manufacture and again at the end of the storage period. 'hese results are given in Table 30. There appeared to be a general endency for a regular increase in mold count in the unsalted butter. 'he salted butter with one exception showed a gradual decrease in the nold count. In the unsalted butter the yeast counts showed no signifiant trend but in the salted butter there was a rather consistent decrease n counts during storage. As far as the bacterial counts are concerned, hree of the samples of unsalted butter gave an increase in count after ne month and then a lower count appeared after nine months. With ne exception, there was a general trend downward in the bacterial ounts of the salted butter.

Table 30

'omparison of Counts of Butter of Same Churning When Fresh and After Storage of One and Nine Months

Churning No.	Unsalted butter			Salted butter		
	Fresh	After one month	After nine months	Fresh	After one month	After nine months
Mold Counts per cc.						
385	9	140	.. 500	5	4	0
469	60	950	10,000	40	15	13
553	1	6	650	1	1	3
151	12	2,700	110,000	9	3	0
Yeast Counts per cc.						
385	660	80	110	90	2	0
469	40	0	250	300	24	36
553	5	21	140	10	2	0
151	23	1,000	0	19	1	0
Bacterial Counts per cc.						
385	158,000	138,000	450,000	7,500	4,400	280
469	1,400	2,370,000	2,020,000	38,000	2,300	900
553	1,420	1,620,000	20,000	1,750	510	200
151	11,800	2,700,000	200,000	3,700	9,300	200

Discussion

During this investigation there was an opportunity to record the lata relating to the quantitative changes occurring in the microflora of outter during its manufacture and subsequent storage. This butter was nade in a typical creamery under practical conditions and the observaions were made over the period of a year. For these reasons the esults may be taken as more or less representative of what might be expected in other creameries (of which there are many) operating under similar conditions.

The cream brought to this creamery was graded as sweet and pe fectly satisfactory for the manufacture of high-grade butter. Never theless, every sample of raw cream was heavily seeded with molds yeasts, and bacteria. If butter had been made from such raw crean there might be some question as to its keeping quality, if one agree that micro-organisms may play an important rôle in the deterioratio of butter.

One of the outstanding facts observed in this study was the effi ciency of the methods of pasteurization used. As a result of this pas teurization, the cream apparently was eliminated as an original sourc of molds in the butter made from it. The yeasts were largely destroye and the number of bacteria was greatly reduced. This simply demon strates that one of the first steps in the control of the microflora o butter is the thoro pasteurization of the cream.

In these studies, the churn appeared to be the most consistent an the most prolific source of molds and yeasts in the butter. This agree with the observations of many other investigators. The churn is th piece of equipment most difficult to clean and at the same time th easiest to neglect. The pipes and pump were not found, in most in- stances, to be important sources of molds or yeasts. However, th occasional appearance of these organisms in the rinse water from suc equipment suggests that the pipes and pumps may, if neglected, lea to contamination of the cream transferred through them. Every piec of creamery equipment that comes into contact with cream must b adequately cleaned and sterilized daily. It is of little avail to pasteuriz the cream if it is to be subjected to constant recontamination throughou the processing in the plant. Parchment paper and cloth circles nee not be important sources of micro-organisms if they are properl handled. They were of minor importance when treated as they wer in this creamery. Water from a properly constructed deep well, pipe directly to the churn or stored in a clean, protected tank, should not b a serious source of micro-organisms, especially of molds or yeasts. Th water in this creamery was excellent and did not contaminate the butte to any appreciable extent. The creamery air was found to contain con- siderable numbers of molds and yeasts, particularly during the summer months. The contamination coming from the dust of the atmosphere may be of importance, especially in the surface molding of butter. This emphasizes the desirability of good ventilation and frequent painting to retard mold growth on walls and ceilings, and also the advisability of eliminating, as far as possible, all overhead piping and similar ob- structions that serve as dust collectors. In this study, the salt was not found to be a source of molds and yeasts. However, if it is exposed to dust or kept in a damp place, it may readily become a source of these organisms.

It is recognized that there are other possible sources of micro-rganisms in butter, such as the starter, the hands or clothes of the perator, and the wooden packing and printing devices. These may, in ome instances, be worthy of consideration. Any source, however rivial it seems on first thought, must be regarded as having the possi-ility of becoming a major factor in the contamination of the butter. Above them all looms the churn, especially, as a source of yeasts and nolds. Thoro pasteurization and adequate sanitation must be practiced the micro-organisms in butter are to be kept at the minimum.

It is generally reported that after the churning of cream the majority f bacteria are discharged in the buttermilk, leaving a small percentage f the original number in the butter. This assumes that the churn or ther equipment does not contribute bacteria. In these studies, it was ound that, as a rule, this occurred but there were instances in which ne bacterial count of the butter was higher than that of the buttermilk, n fact some counts were higher than in the cream itself. This indicates nat the churn and the workers were sources of contamination. In respect o the mold and yeast counts, a larger percentage of the butter counts ere higher than those on the buttermilk or the cream. This proves con-lusively that the churn and the workers were adding appreciable num-ers of mold and yeasts. One must face such a condition and realize nat a great deal more attention must be paid to churn sanitation, under ractical creamery conditions.

The number of micro-organisms in the raw cream was found to be ighest in summer, as might be expected, as summer conditions en-ourage the growth of molds, yeasts, and bacteria. In the case of ne molds, contamination may be greater in the dusty summer months, specially at harvest time. The fluctuations at the other seasons may e explained largely on the basis of modification of cooling procedures s well as the difference in the weather. The proper cooling of cream t all seasons is distinctly indicated.

It was hoped that in connection with the studies on the seasonal ariation in the mold count some clue might be uncovered as to the eason why moldiness in butter appeared to be more frequent during ne spring and summer months. Unfortunately, none of the observa-ons gave any basis for an answer to this question. Some factors must nfluence this phenomenon, but more intensive studies must be pursued efore any knowledge is available concerning it.

The data relating to changes taking place in the microflora during torage are very interesting. It is granted that the storage temperatures ere not so low as those used in commercial cold storage, but no attempt as made to duplicate such conditions. The majority of samples of nsalted butter showed increased bacterial counts after storage of one or nine months at 35° F. This increase was much more frequent an more marked in the case of the samples kept for one month. The da indicate that the number of bacteria in the unsalted butter reached maximum in about ten days, after which there was a gradual decreas It was not always sufficient, however, to bring the counts below tho of the fresh butter. In the salted butter, a large percentage of th samples exhibited decreasing bacterial counts during storage, in bo the one month and the nine months period.

The mold counts of the unsalted butter showed a tendency to i crease during storage, more markedly during the nine months. The mo counts of the salted butter decreased in a majority of samples in o month storage but there were nearly as many increased as decrease counts in the nine months group. This might suggest that the mol most sensitive to salt disappeared in the early stages; the others co tinued to develop.

In the yeast counts, there was a marked tendency for increase counts in the unsalted butter and an equal but opposite tendency f decreasing counts in the salted butter. Both tendencies were mo marked in the butter stored for one month.

In view of the fact that the unsalted butter suffered serious d terioration in storage, manifested by the development of an unclean cheesy flavor, and at the same time witnessed a tendency for increasi numbers of micro-organisms, it is possible to suggest that there mig have been some relationship between the microflora and the defects th appeared. This is a more justified assumption when one notes that t tendency was for a reduction in the number of molds, yeasts, and ba teria in the salted butter while the quality remained reasonably sati factory. Naturally, the mere numerical relationship is not implie rather the fact that if some types can develop there is no reason wh they might not be the species that might produce deleterious chang if present even in small numbers.

Salt, very clearly, had a marked effect on the keeping quality the butter. The higher the percentage of salt in the butter, the great the tendency to check the growth of yeasts and bacteria. The effect increased concentrations of salt was not so marked against the mold because, apparently, the molds that are most susceptible to salt a sensitive to the minimum amount in any of the samples.

The results, in general, give a picture of the fluctuations occurri in the microflora of butter during its preparation and storage such might appear in any typical creamery operating under conditions simil to those existing at Albert Lea, Minnesota. The effects of efficie pasteurization, adequate sanitation, and salt in the butter are clear demonstrated. Many interesting phenomena appear, but they mu await further study before an adequate explanation can be found.

SUMMARY

1. Data, taken over a period of one year, are presented concerning e quantitative changes taking place in the microflora during the manu- cture and storage of butter at a typical Minnesota creamery.

2. Mold, yeast, and bacterial counts of raw and pasteurized cream, eam in the churn, buttermilk, unsalted and salted butter are given for 5 churnings.

3. Results of the study of various sources of micro-organisms in e creamery are reported.

4. Mold, yeast, and bacterial counts are presented for 45 lots of nsalted and salted butters, respectively, before and after storage for ne month at 35° F., and for 64 lots of salted and unsalted butters re- pectively, before and after storage for nine months at 35° F.

5. A seasonal variation was noted in the numbers of micro-organisms raw cream.

6. Pasteurization destroyed 100% of the molds, from 88.98 to 100% f the yeasts, and from 94.20 to 99.99% of the bacteria.

7. The churn was found to be the most prolific source of contamina- on of the cream and butter, especially for molds and yeasts. The in- ction was not serious from pipes, pumps, salt, parchment paper, and e atmosphere.

8. There was a noticeable tendency for increases in the molds, yeasts, d bacteria in the unsalted butters during storage.

9. The majority of samples of salted butter showed decreasing counts iring storage.

10. The higher the salt content of the butter the more marked was e effect on the yeast and bacterial counts. This was not always the se for mold counts.

APPENDIX I

Changes in Mold Counts During the Manufacture of Butter*
(Numbers per cc.)

Month	Churning No.	Raw cream	Pasteurized cream	Cream in churn	Butter-milk	Unsalted butter	Sa bu
July	382	150	0	2	170	33	
"	383	100	0	0	110	3	
"	384	100	0	5	7	20	
"	385	100	0	3	10	9	
August	413	32,000	0	4,000	4,000	4,000	4,0
"	414	1,000	0	2	30	9	[illegible]
"	415	350	0	0	100	70	[illegible]
"	416	330	0	3	80	80	[illegible]
September	441	280	0	0	3	2	
"	442	1,100	0	17	30	20	[illegible]
"	443	190	0	0	6	0	
"	444	20	0	0	28	14	
October	469	70	0	8	340	60	[illegible]
"	471	20	0	0	0	0	
"	472	60	0	16	280	16	[illegible]
November	510	40	0	1	8	0	
"	511	35	0	0	80	12	
"	513	30	0	2	20	8	
December	550	70	0	0	0	10	
"	553	12	0	0	26	1	
"	554	16	0	0	1	0	
January	27	740	0	0	0	0	
"	28	500	0	0	3	0	
"	29	10	0	0	0	0	
"	30	500	0	0	0	0	
"	31	7	0	0	0	0	
February	89	2	0	0	2	8	
"	90	17	0	1	17	12	
"	91	20	0	1	7	8	
"	92	15	0	0	18	0	
"	93	10	0	0	1	1	
March	151	3	0	1	360	12	
"	152	33	0	2	5	0	
"	153	50	0	0	43	4	
"	154	40	0	0	1	2	
"	155	320	0	0	14	1	
April	215	40	0	4	25	7	1
"	216	130	0	4	5	1	
"	217	160	0	4	50	10	
"	218	90	0	0	2	2	
May	272	80	0	0	46	31	1
"	274	80	0	0	12	0	
"	275	150	0	0	0	0	
June	322	100	0	8,000	30	12	1
"	323	150	0	1	20	8	1

* Data taken at Minnesota State Experimental Creamery, 1926-27.

APPENDIX II

Changes in Yeast Counts During the Manufacture of Butter*
(Numbers per cc.)

Month	Churning No.	Raw cream	Pasteurized cream	Cream in churn	Butter-milk	Unsalted butter	Salted butter
ly	382	6,500	0	1	7	120	260
‘	383	1,100	30	20	400	135	106
‘	384	14,500	120	20	430	110	45
“	385	4,900	540	890	550	660	90
ıgust	413	10,000	160	50	60	400	460
“	414	1,400	0	6	70	14	1,000
“	415	850	0	10	220	480	820
“	416	2,000	6	40	260	600	580
ptember	441	300	0	0	4	27	13
“	442	1,500	1	54	33	120	1,180
“	443	1,680	23	10	15	20	25
“	444	750	0	0	1	3	8
tober	469	1,050	0	6	300	40	300
“	471	520	0	1	50	25	16
“	472	200	3	2	60	3	13
vember	510	240	1	1	8	0	6
“	511	300	0	0	10	6	2
“	513	270	0	1	1	1	2
cember	550	900	0	2	9	6	6
“	553	1,480	15	1	33	5	10
“	554	1,290	0	205	3	1	2
nuary	27	500	0	0	0	0	0
“	28	400	0	0	18	0	0
“	29	1,000	0	0	0	6	15
“	30	970	0	0	1	4	3
“	31	90	0	3	2	1	3
bruary	89	1,400	8	1	12	1	8
“	90	1,900	0	6	17	9	20
“	91	740	0	6	2	6	26
“	92	1,510	0	0	18	1	1
“	93	360	370	330	20	15	8
arch	151	50	0	10	80	23	19
‘	152	450	0	0	10	4	7
‘	153	1,020	0	10	17	5	63
‘	154	990	0	1	2	0	5
‘	155	200	0	2	20	8	5
ril	215	540	0	2	3	0	3
‘	216	800	0	0	1	0	1
‘	217	1,300	0	3	8	1	4
‘	218	390	0	0	0	0	0
ıy	272	220	0	1	10	8	6
‘	274	1,200	2	1	13	1	0
‘	275	1,400	0	0	0	0	0
ne	322	1,000	0	0	25	9	8
‘	323	1,200	0	0	12	2	8

* Data taken at Minnesota State Experimental Creamery, 1926-27.

APPENDIX III

Changes in Bacterial Counts During the Manufacture of Butter*
(Numbers per cc.)

Month	Churning No.	Raw cream	Pasteurized cream	Cream in churn	Buttermilk	Unsalted butter	Sal but
July	382	52,000,000	134,000	293,000	1,520,000	110,000	42,0
"	383	26,700,000	76,000	109,000	610,000	29,000	30,0
"	384	19,700,000	297,000	5,600,000	4,400,000	700,000	68,0
"	385	29,600,000	890,000	680,000	950,000	158,000	7,5
August	413	20,000,000	74,000	3,080,000	4,400,000	630,000	32,0
"	414	160,000,000	240,000	8,200,000	15,000,000	1,620,000	72,0
"	415	10,700,000	620,000	1,430,000	9,600,000	640,000	101,0
"	416	....	730,000	3,200,000	2,000,000	63,000	5,0
September	441	26,600,000	24,900	159,000	131,000	9,000	6,4
"	442	20,400,000	14,400	36,000	11,200	2,300	25,9
"	443	12,000,000	37,000	63,000	8,400	8,500	3,5
"	444	4,900,000	44,000	16,300	550	4,500	2,2
October	469	7,400,000	13,900	94,000	97,000	1,400	38,0
"	471	2,210,000	320	4,400	4,000	400	5
"	472	1,520,000	110	120	3,000	200	6
November	510	7,100,000	340	4,600	950	200	2,0
"	511	5,400,000	4,700	3,810	6,400	380	8
"	513	2,400,000	450	1,000	1,000	560	6,3
December	550	15,000,000	1,840	2,330	12,000	600	5,6
"	553	17,700,000	450	44,000	76,000	1,400	1,7
"	554	11,200,000	110	50,000	137,000	2,000	1,6
January	27	28,500,000	890	1,160	5,200	300	2
"	28	3,350,000	1,080	990	27,500	60	1,1
"	29	13,300,000	3,300	2,410	720	3,130	7,2
"	30	10,000,000	2,140	7,700	5,200	6,100	1,6
"	31	10,000,000	4,200	2,900	8,500	980	4
February	89	27,000,000	180	2,020	37,000	2,600	11,9
"	90	57,000,000	3,000	850	67,000	3,100	6
"	91	28,300,000	4,630	4,400	23,400	40,000	17,3
"	92	23,900,000	3,750	5,000	55,000	1,600	1,1
"	93	11,500,000	10,200	13,700	87,000	9,900	11,5
March	151	10,500,000	890	9,700	32,500	11,800	3,7
"	152	20,600,000	900	1,000	4,600	3,100	4,8
"	153	21,600,000	530	2,200	9,700	4,700	12,8
"	154	28,100,000	26,700	36,600	4,000	1,590	5
"	155	18,900,000	730	380	6,100	2,360	4
April	215	10,000,000	3,420	5,200	31,000	2,300	3,5
"	216	17,500,000	7,170	49,200	27,100	37,000	2,4
"	217	14,600,000	7,800	14,800	9,700	1,700	3,2
"	218	4,200,000	39,000	2,760	1,080	860	5
May	272	5,800,000	11,500	19,300	30,000	5,600	2,3
"	274	17,000,000	11,500	24,000	28,000	600	5
"	275	49,000,000	50,000	32,000	17,000	900	8
June	322	23,700,000	32,500	11,300	17,000	1,000	4,0
"	323	16,200,000	37,000	4,400	12,000	420	9,3

* Data taken at Minnesota State Experimental Creamery, 1926-27.

APPENDIX IV

Mold, Yeast, and Bacterial Counts of Unsalted Butter* Before and After Storage for One Month at 35° F. at University Farm†
(Numbers per cc.)

nth	Churning No.	Mold counts Fresh	Mold counts After 1 mo.	Yeast counts Fresh	Yeast counts After 1 mo.	Bacterial counts Fresh	Bacterial counts After 1 mo.
y	382	33	1,500	120	110	110,000	290,000
	383	3	300	135	920	29,000	5,300,000
	384	20	500	110	1,000	700,000	97,000
	385	9	140	660	80	158,000	138,000
gust	413	4,000	150	400	51	630,000	9,000,000
‘	414	9	7	14	0	1,620,000	4,800,000
‘	415	70	1	480	5	640,000	4,200,000
‘	416	80	4	600	12	63,000	1,740,000
ptember	441	2	4	27	14	9,000	1,780,000
“	442	20	2,000	120	2,000	2,300	4,800,000
“	443	0	15	20	100	8,500	90,000
“	444	14	10	3	60	90	1,330,000
tober	469	60	950	40	0	1,400	2,370,000
“	471	0	33	25	25	400	3,600
“	472	16	440	3	3	200	6,700
vember	510	0	5	0	1	200	69,000
“	511	12	7,300	6	5,000	380	170,000
“	513	8	90	1	470	560	124,000
cember	550	10	2	6	20	600	20,000,000
“	553	1	6	5	21	1,420	1,620,000
“	554	0	0	1	16	2,000	10,000,000
uary	27	0	1	0	60	300	43,000,000
“	28	0	1	0	0	60	7,400,000
“	29	0	190	6	1,000	3,130	14,000,000
“	30	0	1	4	0	6,100	16,200,000
“	31	0	0	1	500	980	29,500,000
bruary	89	8	1,850	1	170	8,600	64,400,000
“	90	12	300	9	700	3,100	760,000
“	91	8	21	6	102	39,600	11,100,000
“	92	0	0	1	30	1,600	2,800,000
“	93	1	16	15	7	9,900	660,000
rch	151	12	2,700	23	1,000	11,800	2,700,000
‘	152	0	290	4	190	3,100	1,500,000
‘	153	4	4,600	5	1,500	4,700	3,200,000
‘	154	2	0	0	5	1,590	11,800,000
‘	155	1	0	8	700	2,360	10,400,000
ril	215	7	30	0	100	2,300	13,600
‘	216	1	100	0	10	36,600	10,100
‘	217	10	14	1	120	1,700	60,000
‘	218	2	22	0	150	860	100,000
y	272	31	16	8	17	5,600	230,000
‘	274	0	120	1	17	600	550,000
‘	275	0	5	0	3	900	220,000
ne	322	12	140,000	9	1,000	1,000	300,000
‘	323	8	2,000	2	1,000	420	1,020,000

* Per cent of moisture varied from 10.2–13.7 per cent with the majority of samples ntaining 11.5–12.4 per cent.

† Butter made and examined when fresh at Minnesota State Experimental Creamery, 26-27.

APPENDIX V

Mold, Yeast, and Bacterial Counts of Salted Butter* Before and Afte Storage for One Month at 35° F. at University Farm†
(Numbers per cc.)

Month	Churning No.	Mold counts		Yeast counts		Bacterial counts	
		Fresh	After 1 mo.	Fresh	After 1 mo.	Fresh	Aft 1 m
July	382	18	130	260	40	42,300	36,
"	383	6	40	106	90	30,000	10,
"	384	7	5	45	3	68,000	11,
"	385	5	4	90	2	7,500	4,
August	413	4,000	180	460	83	32,000	3,
"	414	20	2	1,000	48	72,000	5,
"	415	40	1	820	4	101,000	17,
"	416	17	0	580	6	5,000	6,
September	441	0	4	13	10	6,400	4,
"	442	30	20	1,180	660	25,900	13,
"	443	0	3	25	16	3,500	3,
"	444	0	7	8	9	2,200	2,
October	469	40	15	300	24	38,000	2,
"	471	1	0	16	0	560	1,
"	472	26	11	13	8	600	1,
November	510	6	1	6	1	2,000	
"	511	3	0	2	0	860	
"	513	2	0	2	5	6,300	1,
December	550	3	0	6	5	5,600	
"	553	1	1	10	2	1,750	
"	554	2	0	2	0	1,630	
January	27	0	1	0	0	250	1,
"	28	0	1	0	0	1,150	
"	29	0	1	15	19	7,200	5,
"	30	0	1	3	0	1,600	
"	31	0	0	3	1	470	
February	89	2	0	8	3	11,900	2,
"	90	4	1	20	2	600	2,
"	91	7	2	26	2	17,300	1,
"	92	0	0	1	0	1,100	1,
"	93	2	2	8	3	11,500	
March	151	9	3	19	1	3,700	9,
"	152	2	0	7	1	4,800	
"	153	1	0	63	6	12,800	4,
"	154	1	0	5	0	580	1,
"	155	1	0	5	3	440	
April	215	14	3	3	2	3,500	
"	216	2	0	1	0	2,400	
"	217	8	0	4	4	3,200	
"	218	2	1	0	0	580	
May	272	14	3	6	1	2,300	
"	274	0	3	0	5	500	
"	275	0	13	0	12	800	
June	322	19	1	8	0	4,000	
"	323	10	1	8	1	9,300	

* Per cent of salt varied from 2.0–3.7, with the majority of samples containing 2.6– per cent.

Per cent of moisture varied from 15.0–17.2 with the majority of samples contain 15.6–16.0 per cent.

† Butter made and examined when fresh at Minnesota State Experimental Creame 1926-27.

APPENDIX VI

Aold, Yeast, and Bacterial Counts of Unsalted Butter* Before and After Storage for Nine Months at 35° F. at University Farm†

(Numbers per cc.)

nth	Churn-ing No.	Mold counts Fresh	Mold counts After 9 mo.	Yeast counts Fresh	Yeast counts After 9 mo.	Bacterial counts Fresh	Bacterial counts After 9 mo.
y	385	9	500	660	110	158,000	450,000
gust	408	130	400,000	70	100	2,000,000	680,000
"	413	4,000	450,000	400	60	630,000	930,000
	419	2,000	4,900	3,000	0	15,000,000	1,410,000
ptember	426	2,000	2,170	3,000	0	14,300,000	760,000
"	433	210	5,000	1,110	500	5,900,000	970,000
"	440	3	5,000	6	500	3,500,000	350,000
"	448	0	6	720	17	10,400,000	350,000
tober	454	8	10,000	15	800	16,800,000	610,000
"	461	80	15,000	120	1,000	3,300,000	8,100,000
"	469	60	10,000	40	250	1,400	2,020,000
"	475	900	20,000	10	1,000	400,000	690,000
"	476	290	11,000	15	1,200	830,000	7,600,000
vember	485	30	27,000	5	5,000	10,600	3,200,000
"	486	15	14,000	5	3,000	6,500	210,000
"	493	45	20,000	10	1,000	21,200	480,000
"	494	14	25,000	39	600	3,100	1,090,000
"	503	90	20,000	20	700	500,000	670,000
"	504	2	3,000	0	4,000	241,000	3,000,000
"	514	0	13,200	1	140	180	260,000
"	521	10	250	1	1,430	500	120,000
"	522	44	1,400	0	2,000	14,900	720,000
cember	530	47	350	27	23,700	242,000	1,100,000
"	531	0	900	200	34,000	55,000	1,580,000
"	541	7	120	0	8	1,600,000	960,000
"	542	9	5,800	1,660	30	430,000	41,000
"	553	1	650	5	140	1,420	20,000
uary	6	46	12,600	46	4,200	1,680,000	210,000
"	7	28	9,800	2	100	4,700,000	140,000
"	21	7	11,000	10	50	1,690,000	5,000
"	42	2	30	6	2	1,010,000	130,000
"	43	115	4,300	90	150	400,000	20,000
bruary	83	2	1	12	0	4,800,000	39,000
"	84	4	780,000	750	3	16,000,000	10,000
"	97	1	9,200	5	10	165,000	16,400
"	98	32	8,700	41	3,400	410,000	30,000
"	111	2	17,000	12	300	280,000	10,000
rch	125	6	310,000	6	70	154,000	40,000
"	139	1	3,200	10	0	870,000	190,000
"	140	40	4,200	12	5,000	8,800,000	90,000
"	151	12	110,000	23	0	11,800	200,000
"	167	0	800	120	0	37,000	200
"	168	100	400	110	30,000	82,000	2,700,000
ril	180	2	130	1	1,500	10,000	700,000
"	183	3	300	25	60	1,010,000	1,340,000
"	193	2	15	13	25	30,000	490,000
"	194	6	60,000	6	500	480,000	5,600,000
"	209	19	120,000	108	1,000	6,100,000	510,000
"	222	0	110,000	0	0	930,000	110,000
"	223	32	5	56	3,500	6,600,000	40,000
y	236	3	150,000	10	200	3,100,000	110,000
"	237	0	5,700	27	0	1,060,000	200,000
"	254	0	5,000,000	10	200	15,700	70,000
"	255	4	600,000	30	3	700,000	1,280,000
"	266	0	310	40	2,000	24,900	500,000
"	267	12	0	17	20,000	37,000	4,000,000
"	280	8	700	9	100	77,000	360,000
"	281	5	650,000	20	100	18,500	200,000
"	294	19	27,000	20	1,500	34,000	800,000
"	295	5	320,000	1	0	1,400	340,000
ne	308	17	90	19	0	1,000	16,000
"	310	35	1,500	10	100,000	130,000	1,140,000
"	336	0	1,000	2	0	4,100,000	1,340,000
"	337	13	44	1,200	65	350,000	400

* Per cent of moisture varied from 10.2-16.6, with the majority of samples containing 0-11.8 per cent.

† Butter made at Minnesota State Experimental Creamery; examined and stored at iversity of Minnesota.

APPENDIX VII

Mold, Yeast, and Bacterial Counts of Salted Butter* Before and Afte Storage for Nine Months at 35° F. at University Farm† (Numbers per cc.)

Month	Churning No.	Mold counts		Yeast counts		Bacterial count	
		Fresh	After 9 mo.	Fresh	After 9 mo.	Fresh	A 9
July	385	5	0	90	0	7,500	
August	408	36	3	4	0	15,000	14
"	413	4,000	180	460	0	22,000	21
"	419	10	1	1,160	2,410	12,300	10
September	426	80	5	2,720	40	29,100	
"	433	2	16	110	37	6,800	
"	440	1	25	4	4	12,900	1
"	448	0	16	10	0	10,700	
October	454	5	3	40	3	3,300	4
"	461	3	80	40	1,500	3,500	16
"	469	40	13	300	36	38,000	
"	475	2	4	12	3	15,500	
"	476	7	19	14	0	5,400	1
November	485	1	1	9	0	2,560	1
"	486	4	6	3	0	3,100	
"	493	4	7	4	1	10,800	
"	494	8	1	46	6	3,700	
"	503	0	1	3	0	165,000	2
"	504	0	6	1	0	76,000	3,
"	514	0	2	17	48	11,000	1,
"	521	2	2	3	48	500	1,
"	522	0	10	5	500	1,450	
December	530	10	4	11	34	11,900	2,
"	531	0	6	15	1	1,320	
"	541	0	1	1	0	210	1,
"	542	14	0	10	12	780	5,
"	553	1	3	10	0	1,750	
January	6	0	1	4	0	2,200	
"	7	0	1	6	0	79,000	
"	21	3	0	10	0	9,500	
"	42	3	0	1	0	9,300	
"	43	3	0	0	0	230	
February	83	4	0	2	0	6,000	
"	84	0	0	10	0	4,900	
"	97	1	0	3	0	510	
"	98	5	0	20	1	11,600	
"	111	2	0	7	0	3,300	
March	125	3	0	2	0	17,900	
"	139	1	0	9	0	900	
"	140	3	0	10	0	3,200	
"	151	9	0	19	0	3,700	
"	167	0	0	4	17	2,000	7,
"	168	1	0	60	0	6,400	
April	180	1	0	2	150	200	112,
"	183	0	0	0	1,000	2,900	24,
"	193	1	0	17	150	7,800	135,
"	194	0	0	32	0	1,300	
"	209	4	0	8	0	800	
"	222	0	170	0	30	530	2,
"	223	1	4	0	0	3,200	
May	236	1	0	1	0	1,400	
"	237	2	1,700	2	0	1,400	
"	254	0	23	2	0	110	
"	255	2	56,000	28	9,000	350	120,
"	266	0	0	3	13	640	
"	267	0	0	6	0	1,480	
"	280	2	0	0	2	350	
"	281	9	0	5	200	840	4,
"	294	21	30	11	20	1,100	
"	295	3	2	1	48	2,000	120,
June	308	5	100	6	2	167,000	67,
"	310	11	1	7	14	380	7,
"	336	3	200	3	0	200	
"	337	3	0	9	100	2,700	1,

* Per cent of salt varied from 1.6-3.2, with the majority of samples containing 2.4 per cent.

Per cent of moisture varied from 14.2–16.4, with the majority of samples contain 15.8–16.0 per cent.

† Butter made at Minnesota State Experimental Creamery; examined and stored University of Minnesota.